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Hotbeds for Sweet Potato Plant Production in Louisiana

Wiley D. Poole



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Louisiana State University
and
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Charles W. Upp, Director

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Hotbeds for Sweet Potato Plant Production in Louisiana

WILEY D. POOLE
Agricultural Engineer

Farmers are aware of the importance of setting out sweet potato plants just as soon as possible after the danger of a late frost has passed. Having early plants available for field setting has many times resulted in additional cash returns to the farmer, because he was thus able to harvest early and take advantage of a higher price paid for early potatoes. In general, early planting has enabled the farmer to enjoy a longer growing season and to complete harvesting before the rainy season in the fall.

Except in the most southern part of the sweet potato area of Louisiana, it is advisable to utilize some type of hotbed for producing sweet potato plants large enough for field setting immediately after the danger of late frosts. In this bulletin consideration will be given to the most suitable location and types of hotbeds, as well as the means for heating them under Louisiana's climatic conditions.

Location of the Hotbed

Hotbeds should always be located on a well-drained site that is free from low spots and which will not flood during heavy rains. A location near the house where the beds can be given frequent attention is desirable. The artificial heat supplied to the hotbed is a supplement to the heat supplied by the sun; therefore, the hotbed should be located so as to be exposed to the sun as much as possible and also protected from the north wind. In locating the hotbed consideration should be given to the convenience of piping water to the bed, and also gas or electricity, whichever is to be used as a source of heat. If the location is on a slight slope, a drainage ditch should be dug on the uphill side to prevent rain water from entering the bed.

Size of Hotbed

Figure 1 shows three typical sizes of hotbeds which are laid out to use most economically the standard lengths of electric heating cable kits. Some of the larger commercial plant growers prefer the wider hotbed shown in Figure 4. The size and number of hotbeds needed by a farmer will depend on the acreage to be planted as well as the method to be used for planting this acreage. A small acreage might well be planted with slips from the hotbed, or a larger acreage may be planted from vine cuttings taken from early hotbed slips which were planted in the field. In determining the size of hotbed needed it should be remembered that approximately 12,500 plants are needed to set one

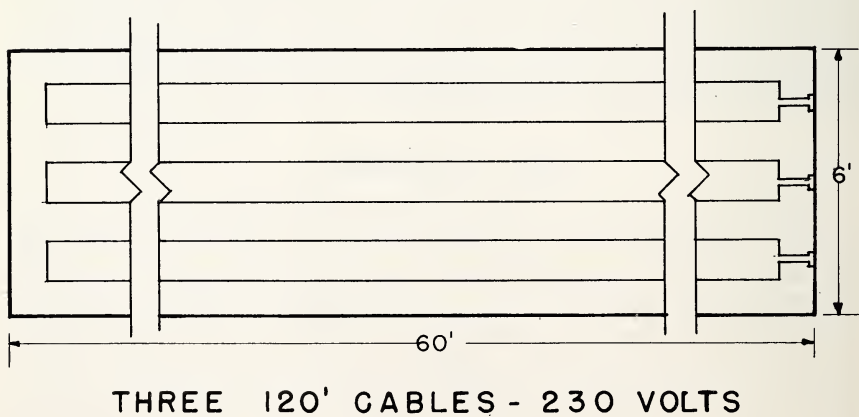
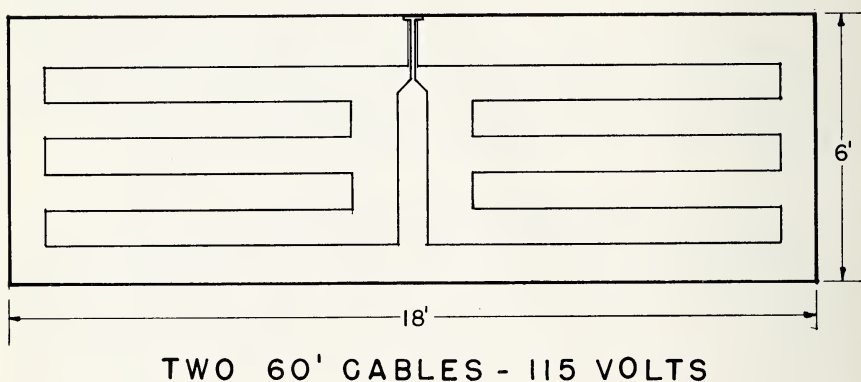
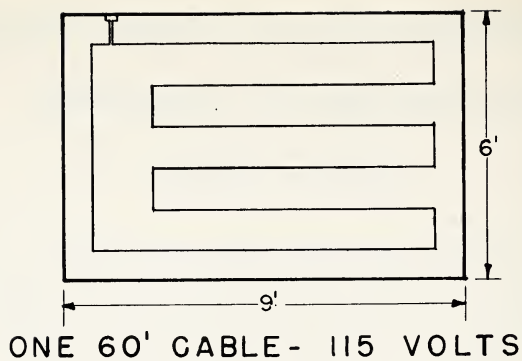


FIGURE 1.—Typical sizes of electrically heated hotbeds using electric heating cable.

acre of sweet potatoes on rows $3\frac{1}{2}$ feet apart when the plants are spaced about 12 inches apart in the row.

Table 1 gives the number of plants needed to plant one acre for various row widths when plants are spaced 8, 12, 18 or 24 inches.

TABLE 1.—Number of Plants Required for Setting Out an Acre for Various Row Widths and Various Plant Spacings on the Row

Row spacing	Spacing of plants on the row			
	8 inches	12 inches	18 inches	24 inches
36 inches	21,800	14,520	9,680	7,260
42 inches	18,700	12,444	8,296	6,222
48 inches	16,350	10,890	7,260	5,445
54 inches	14,666	9,680	6,453	4,840
60 inches	13,200	8,712	5,808	4,356

Results of various investigations indicate that, for hotbed setting, small roots will produce more plants than the larger roots. Edmond and Dunkelberg (1) found that crowding the roots in the hotbed increased substantially the number of plants per unit of area. This also appreciably reduced the labor and heat requirements per given number of plants. Therefore, to get the most out of the hotbed space, it is recommended that as many roots as possible be placed in the bed so long as they do not touch one another. Not allowing the roots to touch is a precaution to prevent rotting; however, research data indicates that touching of roots in the hotbed will not increase rotting if the seed stock is healthy and free from disease to start with.

A bushel of U. S. No. 1 seed sweet potatoes will generally produce in a hotbed 2,000 to 2,500 plants from a total of three or four pullings. A bushel of U. S. No. 1 seed potatoes will occupy about 15 square feet of hotbed space.

Materials and Methods for Constructing the Hotbed

The Frame

A well-constructed hotbed frame should be free of cracks which might let the heat escape. The cover should fit snugly to the frame on all sides. A suitable frame can be built of lumber 1 inch thick with the main supporting members made of 2-inch by 4-inch battens and stakes. If the bed is to be used for several seasons, then the lumber should be of a type such as cypress or cedar or treated lumber which will withstand the weather. Figure 2 shows a cross section of a typical hotbed 6 feet wide with sides made of lumber. This type of hotbed is designed to use either glass sash or cloth as a cover. The suggested lengths for this type of hotbed when electric cable is used for heating are shown in Figure 1.

For a more permanent installation the sides and ends of the hotbed can be made of brick, concrete block or similar long-lasting materials. There are a number of hotbeds of this type in Louisiana

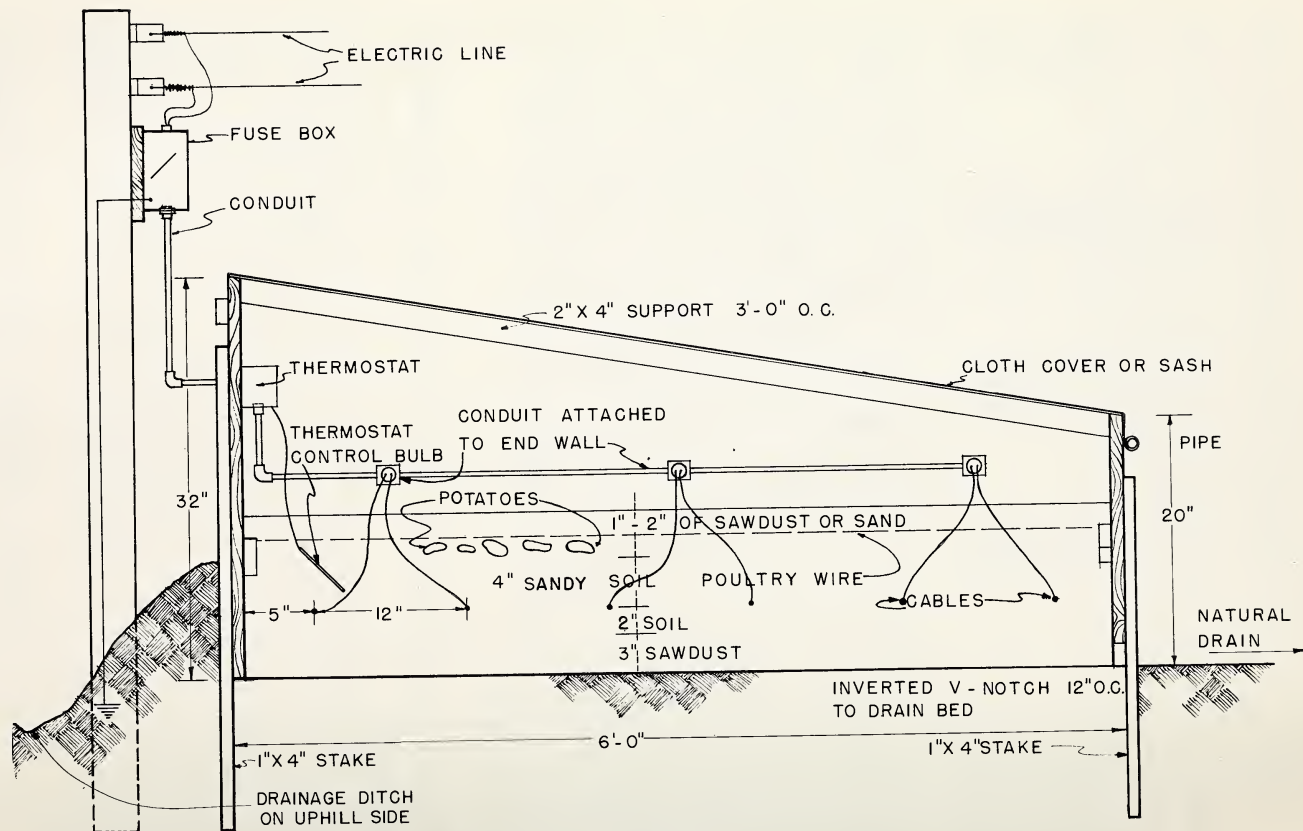


FIGURE 2.—Cross section view of a typical sash or cloth covered, electrically heated hotbed.

operated by large commercial plant growers. These beds are usually 10 feet wide and have a gable type of cover framing as shown in Figure 4.

The length of these hotbeds is usually 60 to 100 feet when hot water is used for heating and either 30 or 60 feet when electric heating cable is used.

It is not necessary to excavate below the ground surface in building the artificially heated hotbeds.

The Cover

The material for covering the hotbed should be given careful consideration because it will greatly affect the over-all cost of operating the beds over several seasons. Some materials, if carefully handled, will last many seasons while others will be so affected by weather that only one or two seasons is all that can be expected from them. Glass sash cover probably has been used the longest and will last longer than any other type of cover. It is also the most expensive to use because of the cost of the frames and glass. For this reason it has lost popularity for large installations.

Recent introduction of polyethylene film has offered a new type of translucent cover for hotbeds. It can be obtained in widths that will fit any commercial bed and in 100-foot rolls. This material can also be obtained as a black film which seems to stand the weather better than the translucent but must be rolled back off the bed to allow sunlight to the plants. Film thickness should be at least 4 mils. If polyethylene is used as a cover, careful attention must be given to properly ventilate the beds by removing the cover when the sun shines,



FIGURE 3.—Sweet potato hotbeds with covers made of lightweight wood sash frames covered with heavy 5-mil clear plastic.

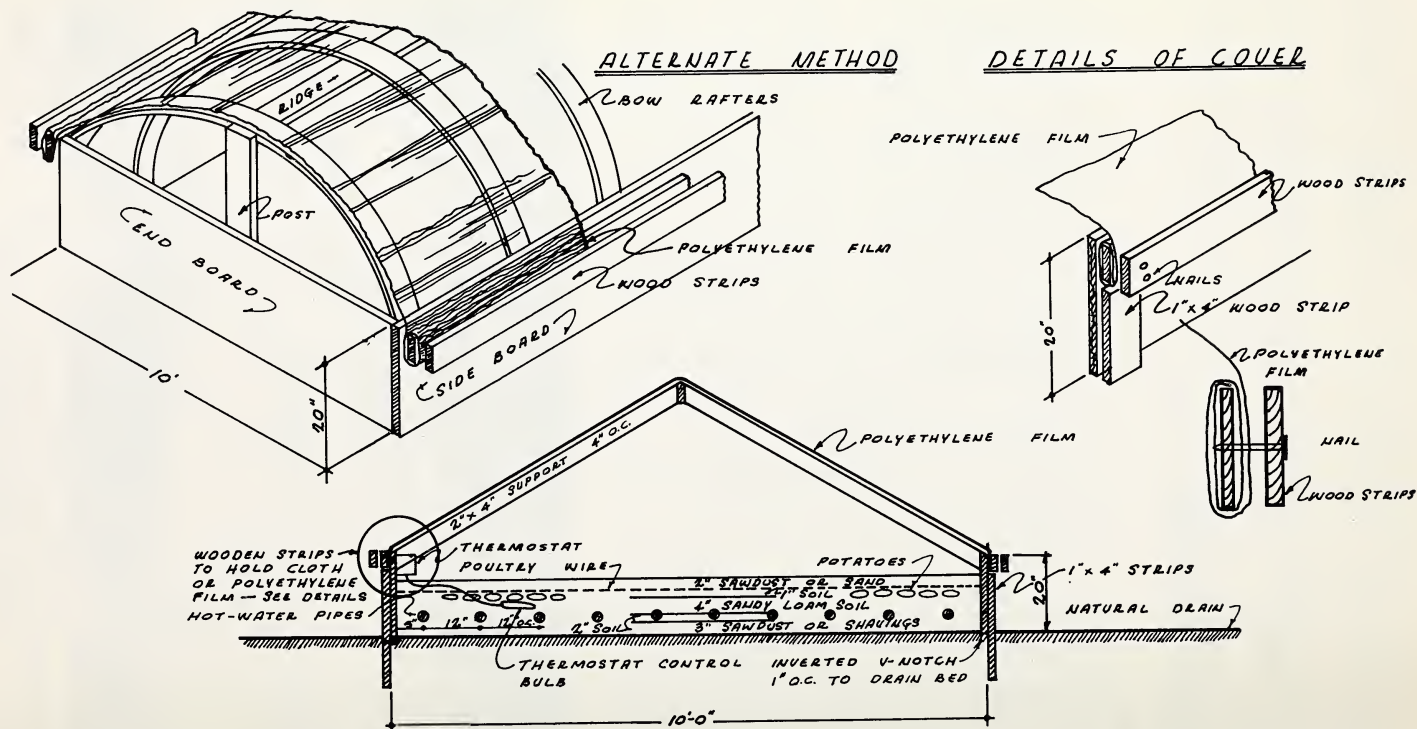


FIGURE 4.—Typical gable type wide hotbed used by commercial growers.

to prevent very high temperature from building up under the cover, which would injure the plants. The film must be protected from sharp points, corners, or nails, as it will rupture easily. It must also be stretched tight over the supporting frames to avoid flapping or sagging. Figure 3 shows hotbeds with covers made of lightweight wood frames covered with 5-mil clear plastic.

Heavy cloth such as muslin has been used extensively as a hotbed cover on large installations. Experiments comparing glass sash and cloth cover, conducted by engineers of the Louisiana Agricultural Experiment Station, showed that under Louisiana conditions the cloth cover produced plants at a slightly lower consumption of heat, but the glass sash produced plants slightly earlier than the cloth covered hotbeds. Cloth covered hotbeds do not have as great a change in temperature due to sunshine as the plastic covered hotbeds. Cloth covers are fastened to the hotbeds and can be rolled up the same as the plastic film covers as shown in Figures 2 and 4. One side of the cover should be attached to a roll as this makes the job of rolling the cover back for ventilation easy. This roll should be wired to the hotbed frame to prevent air currents from getting under the cover and tearing it. Figure 5 shows large hotbeds using muslin as a cover. Notice that there is no sag in the cloth cover over the hotbed.



FIGURE 5.—Large commercial hotbeds using muslin cloth as a cover.

Insulation

Because of the reasonably mild weather during the period of operating the sweet potato hotbeds, the use of commercial insulation in these hotbeds is not recommended. However, the use of insulating materials that are obtainable around the farm at no additional cost, such as pine straw, sawdust, chopped corn cobs or chopped hay, is recommended. Ordinarily, heat loss through the soil under the hotbed

is small as compared to the losses through the sash and frame. Research studies were conducted to determine to what extent the heat consumption of a hotbed could be reduced by utilizing from 3 to 4 inches of farm waste material such as pine straw, chopped hay or cornstalks, or wood shavings under the heating cables or pipes in the hotbed. Results of these experiments showed that an average saving in heat consumption as great as 15 to 20 per cent could be expected from use of such insulation. This insulating layer is shown in the cross section drawing of a hotbed in Figures 2 and 4.

It is also recommended that farm waste insulating material as mentioned in the above paragraph be piled around the outside ends and sides of the hotbed to give further protection from the cold air. All cracks in the hotbed should be sealed to prevent leakage.

Bedding Media

A sandy loam type of soil has been used more extensively than any other material for bedding sweet potatoes in hotbeds. Sand and sawdust are sometimes used, but if no additional plant food is to be added to the bedding media, it is recommended that a sandy loam soil be used. Edmond and Dunkelberg (2), when comparing soil and sand as a bedding media, found little difference, if any, in total plants produced when equal amounts of commercial fertilizer were added. However, a great deal of difference in favor of soil existed when soil alone and sand alone were compared. It would seem then that the most influential factor in the bedding media for producing plants is the plant food present. Therefore, it is recommended that commercial fertilizer be added to and thoroughly mixed with the bedding media to increase plant production of the hotbed. The rate of fertilizer application should be approximately 300 to 350 pounds per acre of the type recommended for the area.

If a fine loam soil is used as a bedding media there is danger of a crust forming from frequent watering. To prevent this it is recommended that a layer of 1 to 2 inches of sawdust or sand be placed on top of the bedding soil. To prevent moving or disturbing the mother potato when pulling slips, a layer of poultry wire should be placed over the entire bed after the sweet potatoes are placed in the hotbed. The location of the poultry wire, sawdust, etc., is shown in the cross section view of a standard hotbed in Figures 2 and 4.

Methods of Heating Hotbeds

Many research workers have conducted experiments to determine the optimum temperature to hold the sweet potato hotbeds for the most economical plant production. It is generally considered that the temperature of the potato should be between 80° F. and 85° F. Edmond and Dunkelberg (2) narrowed this range down to 83° F. to 85° F. The more closely the optimum temperature is maintained within a sweet potato hotbed, the greater will be the efficiency of plant production.

In south Louisiana it is a common practice to depend upon field setting for plants. However, adverse weather conditions such as cold rains or a late cold spell render this practice very uncertain for the very early slips. Table 2 gives the average minimum temperature for the various sweet potato areas of Louisiana during the three months in which sweet potato plants are being grown for field setting. It is obvious that these probable low temperatures are far below the recommended temperature for favorable plant growth.

In several southern areas of the state hotbeds are sometimes used without any source of heat other than the sun's rays during the day. The frame and cover for such hotbeds are the same as those for the heated type. During cold spells or cool nights the hotbed frame and cover offer some protection and tend to hold the heat accumulated during the day.

Another practice used to speed up plant production is to cover the top of the seedbed in the field with polyethylene film as previously described under "Hotbed Covers." This plastic film allows the soil to absorb much of the sun's rays during the day. Heat thus absorbed is transmitted to the seed potato in the row. The plastic film will also protect the row from cold winds and tend to hold the heat in the row.

TABLE 2.—Average Minimum Temperature in Degrees Fahrenheit for the Sweet Potato Areas of Louisiana

Area	Length of record (years)	March	April	May
Shreveport	56	48.8	56.3	63.6
Alexandria	36	49.3	55.5	62.6
Monroe	43	47.1	54.5	62.0
Baton Rouge	43	51.7	58.0	64.1
St. Francisville	19	49.5	55.3	62.4
Opelousas	26	50.1	55.8	62.6
Lafayette	38	51.2	57.1	63.3

Probably the oldest method of supplying heat to hotbeds is the use of fermenting horse or mule manure. Because of the scarcity of the manure, the danger of spreading sweet potato diseases, and the larger amount of labor required for setting up this type of hotbed, its use has rapidly declined. Also, there is no way to control the heat in this type of hotbed. This method is no longer recommended.

Another method that was used extensively when labor was more plentiful was flue heating. Hot flue gases were used in several ways to heat the hotbeds. Usually one or two ditches were dug in the bottom of the hotbed and covered with some type of metal. Soil was then placed over the metal covering and the sweet potatoes bedded in the soil. At the end of the bed was a fire box of some type where a wood or gas fire furnished the hot flue gas. This type of hotbed required much labor and attention at all times during the growing season. There was danger of overheating or underheating the beds when using inexperienced labor for firing the fire box. Thus when

other methods of heating the hotbeds were developed which could be automatically controlled, this flue-heat method was quickly discontinued.

Electrically Heated Hotbed

A special flexible, electric soil-heating cable has become a popular means of heating hotbeds in Louisiana. Popularity of the soil-heating cable can be attributed to several factors. One is that recently electricity has been made available to practically all farmers. Electrically heated hotbeds are thermostatically controlled and therefore require very little tending; at the same time, the hotbed maintains a very constant heat even with fluctuating outside temperatures. They require less labor to construct, and no fuel has to be hauled and no firing done. This is probably the best method of heating for the farmer who wants to put in one 6 by 9 or 6 by 18-foot bed as shown in Figure 1.

The lead-covered soil-heating cable consists of a high resistance conductor covered with felted asbestos, varnished cambric, and a protective lead sheath. Because of its electrical resistance it must always be used in a 60-foot length on a 115-volt circuit or a 120-foot length on a 230-volt circuit. The 60-foot length is rated at 400 watts and the 120-foot length at 800 watts.

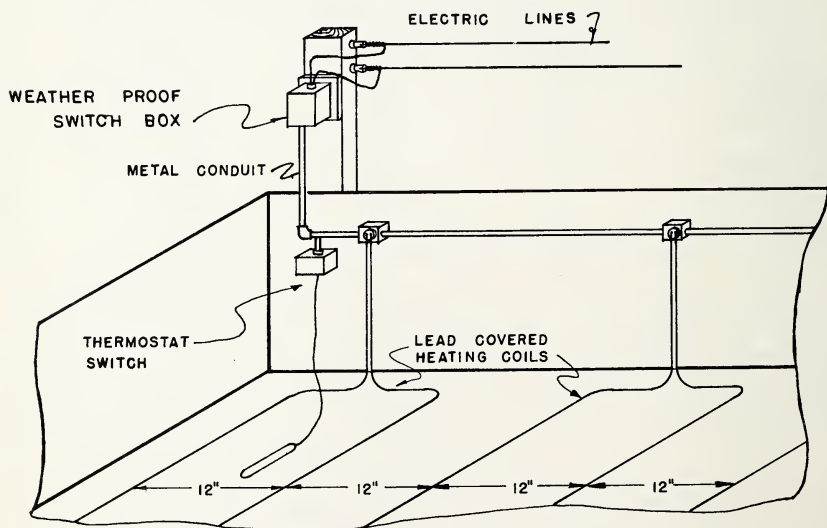


FIGURE 6.—Wiring diagram for electric cable heated hotbed.

Results of tests under Louisiana conditions show that about 7 watts per square foot is all the heat necessary for growing sweet potato plants in a hotbed. On the basis of this figure for heat requirement and the standard lengths of electric cable (60 feet for 115 volts and 120 feet for 230 volts), three sizes and placement of electric heating cable for each size are shown in Figure 1.

Some companies now offer soil heating kits which consist of one soil thermostat with plug receptacle attached and one or two 60-foot lengths of heating cable. The heating cable in this case will have a heavy-duty male plug on the end for plugging into the receptacle. Figure 6 shows the standard kit unit plus a switch box.

For large installations where large quantities of the heating cable are to be used, it is more economical to buy the heating cable in bulk quantity in multiples of 60 or 120 feet. The bed can then be wired by the farmer or an electrician in a manner shown in Figures 6 and 7. The proper size wire for conveying electricity to the beds can be obtained from Table 3.

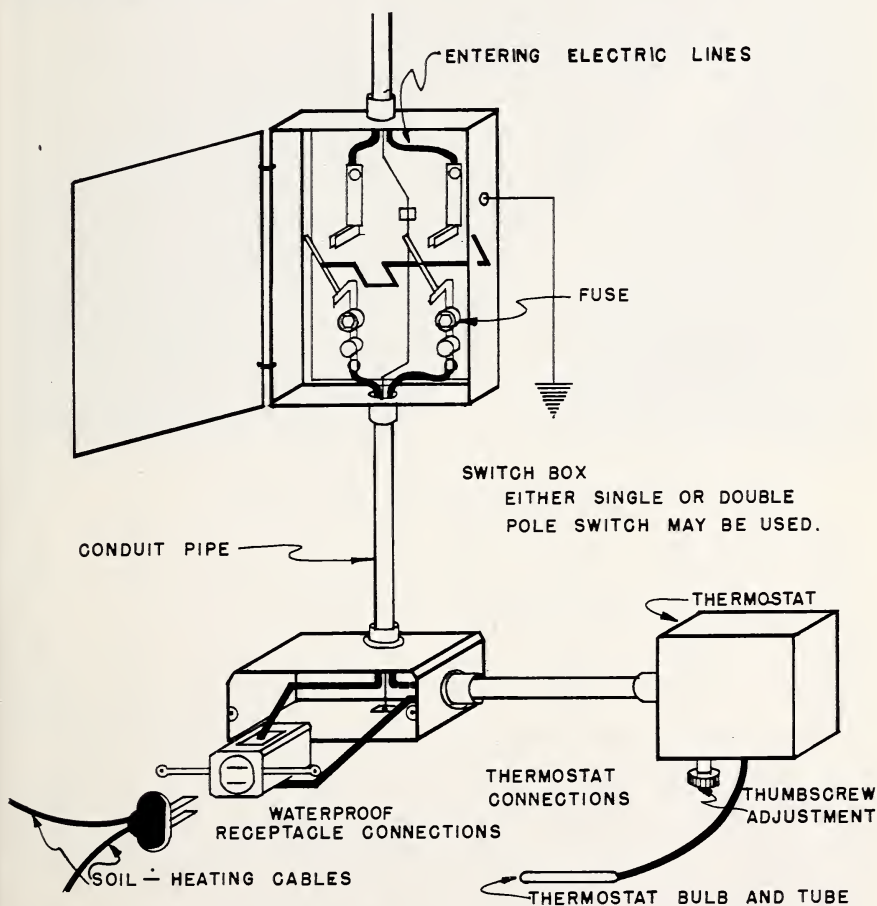


FIGURE 7.—Installation of the thermostat, switches, and receptacles in an electric cable heated hotbed.

Several manufacturing companies have recently developed a heating cable covered by a plastic sheath in place of the lead sheath. These cables are much lighter than the lead-covered cables and are easy to

handle. The heating value per foot of this cable is usually slightly less than that of the lead-covered cable; therefore more is used for the same size hotbed. The wattage of these plastic cables is always given in the literature on the cable. Make sure that at least 7 watts per square foot of hotbed is used.

The general construction of the hotbed frame and selection of a suitable site for the hotbed are the same as covered in previous paragraphs under these topics.

It is known that the roots produce the maximum number of plants when held between 83° F. and 85° F. Therefore, in order to maintain an even temperature at the level of the roots in a hotbed, the heating cable should be placed at a definite depth below the roots for a given spacing. Studies on this subject were conducted under controlled conditions in the laboratory. Results of the tests indicate that a uniform temperature in the hotbed at the level of the bedded roots can be obtained if the depth of the lead-covered cable below the roots is as follows: For a cable spacing of 10 inches, distance of cable under roots should be 3 inches; for a cable spacing of 12 inches, distance of cable under roots should be 4 inches; for a cable spacing of 14 inches, distance of cable under roots should be 5 inches.

TABLE 3.—Wire Size to Use in Running 115- and 230-Volt Extensions, Varying in 100-Foot Lengths, from Metering Point to Hotbeds of Sizes Shown. (These are the Size Wires Required to Keep the Voltage Drop Below the Maximum Allowed for Economical Operations.)

Length of Soil Cable in Feet	Distance (Feet)						
	100	200	300	400	500	750	1,000
		Wire Size	Required	for 115	Volts		
60	10*	10*	10*	10	10	8	8
120	10*	10*	10	10	8	6	4
180	10*	10*	8	8	6	4	4
		Wire Size	Required	for 230	Volts		
240	10*	10*	10*	10	8	8	6
360	10*	10*	10	8	8	6	6
480	10*	10*	10	8	8	6	4
600	10	10	8	8	6	4	4

*Minimum size allowed by National Safety Code for outside overhead conductors.

Figures 2 and 4 show cross section views of a standard 6-foot and a 10-foot hotbed. These figures show the recommended insulating layer between the cable and the ground, the spacing of the heating cable, and distance above the cable for bedding the roots. The sawdust or sand layer above the roots prevents a crust from forming and makes pulling slips much easier. The poultry wire above the roots is to prevent disturbing the roots when pulling slips.

If the hotbeds are to remain in the same location each year, then the bedding soil down to the heating cable should be removed and replaced with fresh soil at the time of bedding the roots in the

spring. In removing this soil it is very easy to cut or damage the heating cable, causing faulty operation. To avoid damaging the cable many operators have covered it with half-inch mesh hardware cloth. Damage from cable cutting can be very expensive. The heating cable and hardware cloth are shown in Figure 8.



FIGURE 8.—Electrically heated hotbed showing electric heating cables in place and hardware cloth to be placed over the cables.

The thermostat plays a very important part in the hotbed operation. It is the instrument that keeps the hotbed at the proper temperature. If its operation is faulty, serious damage might result to the roots in the hotbed. It is recommended that the thermostat be tested each spring before the hotbed is put into operation. The method used for properly adjusting the thermostat is discussed in a later paragraph under "Operating the Hotbed."

Results of tests on the operation of electrically heated hotbeds indicate that, for average conditions, electric heat is supplied to a hotbed for a period of 10 to 14 hours each day. As would be expected, this heat is supplied during the night and practically all day on cloudy days. Data taken on the electricity used on a number of hotbeds for the past several seasons show that the average consumption of electricity for the period of operation is from 4.5 to 6.5 kwh per square foot of hotbed surface. The period of operation is usually 6 to 7 weeks.

Electric light bulbs have been used as a source of heat for hotbeds, particularly for small installations. If properly installed this system is usually higher in cost than the electric cable and has all the disadvantages of breakage and danger of shortages due to dampness and

water when watering the beds. This method is not recommended as a farm installation.

Hot-Water-Heated Hotbed

The use of hot water circulated in pipes buried in the soil of the hotbed has been gaining in popularity among large-scale commercial operators. The frame of the hotbeds using this method of heating is usually the wide gable cover type as shown for the electric bed in Figure 4. The building of the frame and placement of soil, etc. are the same for the hot-water system as has been described for the electric heating cable system. The only difference is that heating pipes are placed where the electric cables are shown in Figures 2 and 4. The hot-water beds are usually 60 feet long, and another bed is set behind the first so that the hot-water pipes can run the full length of the two beds before returning. Figure 9 is a schematic diagram showing all the components that must be used to make a hot-water-heated system.

The principle of operation in the hot-water system is briefly as follows: Water is taken from the open surge tank by the electrically driven centrifugal pump and forced under pressure through the heating coils where it is heated; it is then forced into the hot-water header line, which is a large line that runs at the head of each row of hotbeds; from this header line heated water is forced through pipes that run the length of two beds and return to the head of the beds where they empty into a cold-water header line; the water is returned to the open water surge tank to be pumped again through the system. The duration of operation is controlled by a thermostat just as in the electrically heated system. However, in this case the thermostat makes an electrical connection when the beds become cool, which allows the electric motor to start pumping and at the same time opens a magnetic valve that starts the gas burner under the water coils. When the beds are warm enough, according to the setting of the thermostat, the electrical connection is broken, thereby stopping the electric pump and shutting off the gas burner.

The pipes used in the hotbed can be either $\frac{1}{2}$ -inch or $\frac{3}{4}$ -inch regular screw thread or copper pipe and are spaced 12 inches apart as shown in Figure 9. The header lines running at the head of the beds are $1\frac{1}{4}$ - or $1\frac{1}{2}$ -inch pipe. If the hot-water lines in the hotbeds are longer than 100 feet in one direction, then the $\frac{3}{4}$ -inch pipe is recommended. This will keep the pressure on the pump at a low figure and allow the use of a smaller pump and motor.

The amount of heat supplied the hot-water beds is the same as for the electrically heated beds but is quoted on a BTU basis, which is a standard measurement for heat when dealing with fluids. For the electric beds, 7 watts of electric heat per square foot is the basis for arriving at the required heat. Since 1 watt is equal to 3.412 BTU, the heat load for the hot-water bed will be 7×3.412 , or 23.884 BTU per square foot of bed. (For the purpose of calculating heat load, use

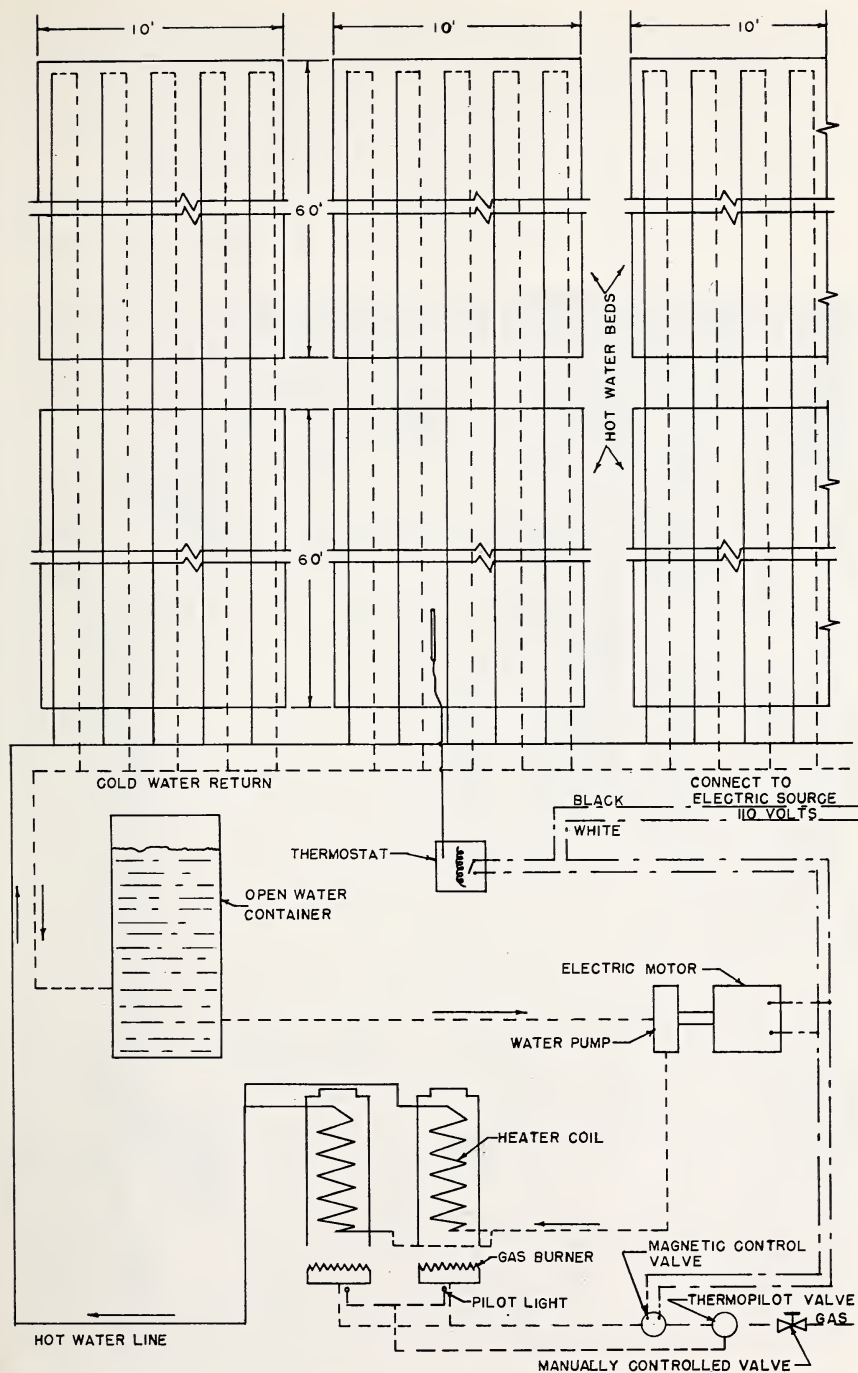


FIGURE 9.—Typical design for a six-bed, hot-water-heated hotbed showing water lines, pumps, hot-water heater, and electrical controls.

24 BTU per square foot of bed.) Multiplying the total area of the hotbeds by 24 will give the amount of heat necessary for the installation. It is wise to allow an additional 4 to 5 per cent of heat requirement to compensate for the heat lost in the header lines. If the header lines are to run as far as 50 feet from the coil heater, then some type of waterproof insulation should be placed on the header pipes.

The Hot-Water Heater.—Hot-water coil type heaters are usually used for heating the water since they are smaller and more compact

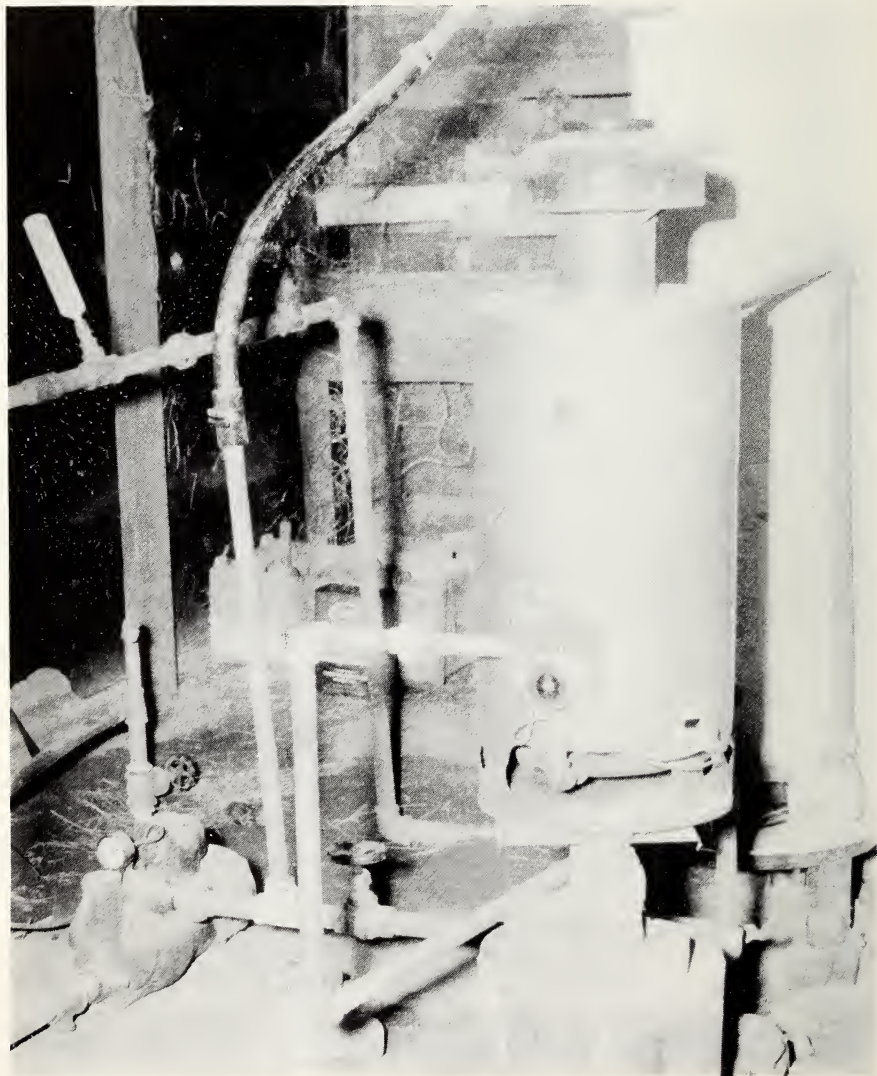


FIGURE 10.—Coil heater and pump for hot-water-heated hotbed.

for a given capacity compared to the regular hot-water tank-type heaters. Figure 10 shows a coil and a tank-type of water heater being used together as a source of hot water for a hotbed installation. It is often necessary to use more than one heater to get the required hot water for a large installation such as shown in Figure 9. To reduce the friction of the water in going through the heater coils, they should be installed in parallel in the system instead of in series. This will divide the water going through each heater and reduce pumping head pressure. The parallel type of connection is shown in Figure 9.

Hot-water heaters, both coil and tank types, together with suitably matched gas burners can be obtained from most hot-water heater manufacturers. These heaters are rated in either BTU per hour (input or output) or recovery rate in gallons of water per hour for a certain water temperature rise in degrees Fahrenheit. If a catalog lists only the recovery rate in gallons per hour for a listed temperature rise, then the output in BTU per hour can be calculated by using the following formula:

BTU per hour = gallons per hour x 8.33 x water temperature rise in degrees F.

Only the output rating can be used in arriving at the proper size heater. Some catalogs will list only the input rating, which should not be taken as the output rating of the water heater. For example, a typical listing for a hot-water heater is as follows: Model 30M, 30 gals. capacity, input rating in BTU per hr. is 30,000, recovery rate in gals. per hr. is 42 for a 60° F. rise. Using the formula given above, the output rating for this heater can be calculated as follows: BTU per hour = 42 x 8.33 x 60. This equals 20,000 BTU per hour output rating. The actual output of a heater unit is usually 30 per cent lower than the input rating. So if only the input rating is listed, reducing it by 30 per cent will give the approximate output in BTU per hour.

The Pump.—From field tests it was found that the average temperature drop of hot water in circulating through the hotbeds is from 10° to 12° F. when holding the hotbeds at a temperature of 83° to 85° F. To maintain this temperature in the hotbeds, the hot water must leave the pump at a temperature of 90° to 92° F. and it will return at a temperature of 78° to 80° F. A reduction in water temperature greater than 12° F. is not recommended. Under these conditions a certain amount of heated water must be circulated. The amount of heated water required can be determined from the following formula:

For a 12° F. reduction in temperature

$$\text{Water in gallons per minute} = \frac{\text{Total BTU per hr.}}{6,000}$$

For a 10° F. reduction in temperature

$$\text{Water in gallons per minute} = \frac{\text{Total BTU per hr.}}{5,000}$$

As an example, assume that the heat required for a hotbed installation is 70,000 BTU per hour and a 10° F. drop in water temperature

is allowed. Then the heated water that must be pumped through the system would be $\frac{70,000}{5,000}$ or 14 gallons per minute.

In selecting a pump to circulate this heated water, not only must the amount of water to be pumped per minute be calculated, but also the friction head that the pump must operate against must be determined. The friction in the pipe will vary with the size of the pipe and the amount of water being pumped through it. The smaller the pipe, the greater the resistance in forcing the same amount of water through it. Figure 11 gives the resistance head in feet of water per 100 feet of pipe for various quantities of water that will be circulated through the hotbed.

To prevent a large temperature drop in the hot-water line in the hotbed, the line connected to the hot-water header is run the length of the bed, then returns and discharges into the cold-water header line. This is commonly referred to as a loop of line. Since these loops of hot-water lines are spaced one foot apart, it takes five such loops for a 10-foot-wide hotbed. If the installation is three hotbeds wide, as shown in Figure 9, then 15 loops of hot-water line are required. Assuming that the amount of hot water to be circulated was calculated to be 18 gallons per minute, then 18 divided by 15 equals 1.2 gallons per minute per loop of line. Assuming that the length of line per loop is a total of 200 feet, then from the graph in Figure 11 the resistance per loop would be .8 foot of head per 100 feet of $\frac{3}{4}$ -inch pipe. Thus for a 200-foot loop it would be 1.6 feet. The resistance, then, for the whole system of $\frac{3}{4}$ -inch hot-water lines would be 1.6×15 , or 24 feet of head. Assuming that $1\frac{1}{4}$ -inch pipe was selected for the hot- and cold-water header lines and that the length of these lines totaled 150 feet, then the resistance for the header lines can be obtained from Figure 11 as 9.2 feet of head per 100 feet of line for 18 gallons per minute. So 9.2×1.5 equals 13.8 feet of head. The total resistance for the system would be $24 + 13.8$, or 37.8 feet of head.

After the gallons per minute to be pumped and the total friction head that the pump must operate against have been determined, a pump can be selected for the hot-water system from a manufacturer's catalog.

Example in Selecting the Heater and the Pump.—The following calculations show how the size of the heating system and motor-pump unit can be determined for a hot-water-heated hotbed such as the one shown in Figure 9. The total area of the six beds will be 3,600 square feet. Using the round figure of 24 BTU per square foot as arrived at previously, the necessary heat to be supplied the hotbed will be 86,400 BTU per hour. Allowing 3,600 BTU for heat loss in the header line will bring the total heat necessary to 90,000 BTU per hour. This heat will have to be supplied by the circulating water.

From a heater company catalog select a coil heater whose capacity in BTU per hour output of heated water equals the calculated heat

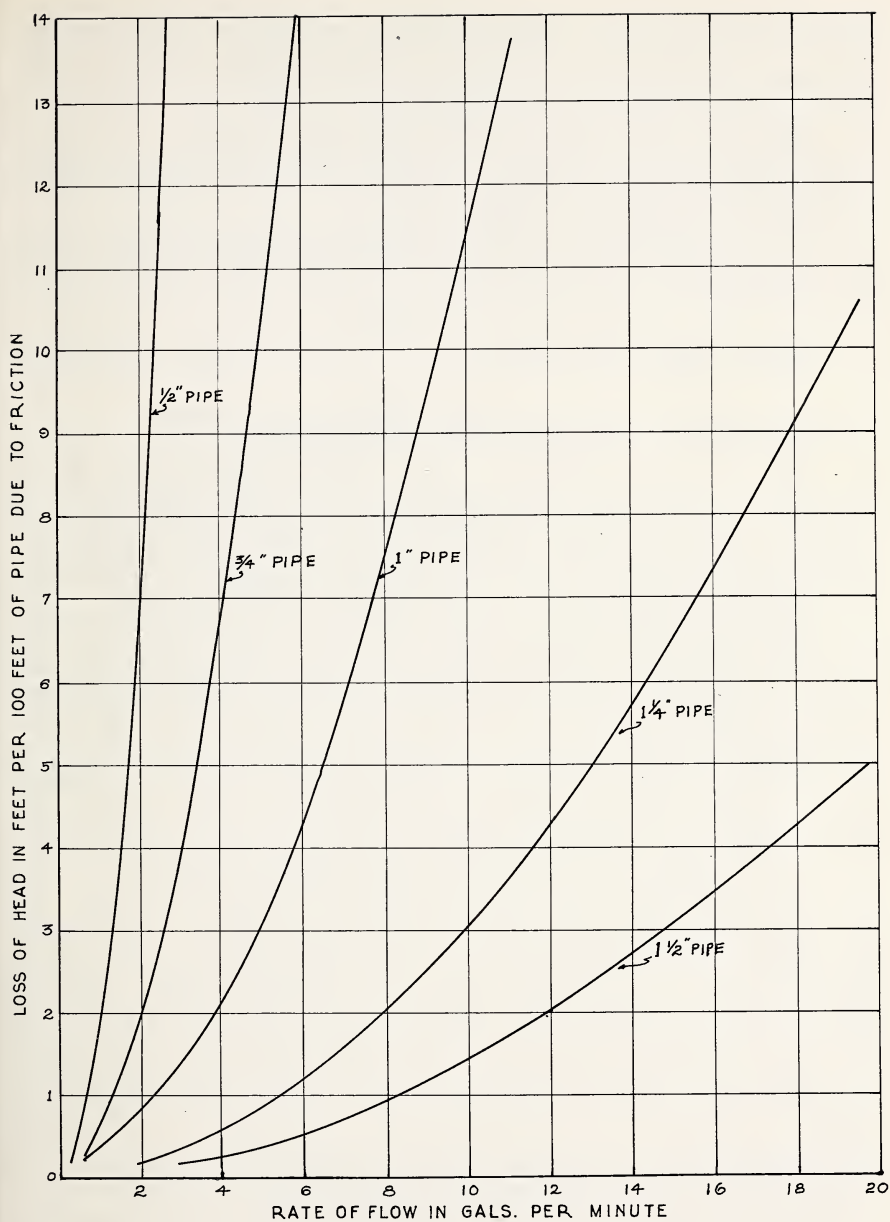


FIGURE 11.—Friction of water in pipes.

required for the hotbed system. It will be necessary to use two heaters as shown in Figure 9. In this event, it is recommended that the heaters be connected in parallel as shown so that the resistance to passing the water through the coils is at a minimum.

Allowing a 10° F. drop in water temperature, the hot water pumped to the beds will be 90° F. and the return water 80° F. The thermostat in the hotbed will be set to hold 85° F.

Using the formula for determining the gallons of heated water to be circulated for a 10° F. drop in temperature (Page 19), calculations are as follows:

$$\text{Water in gals. per minute} = \frac{90,000}{5,000}, \text{ or } 18 \text{ gals. per minute.}$$

This is the total amount of water circulated for all hotbeds.

The hotbeds are laid out so that the water lines run the length of two beds, as shown in Figure 9. The length of one loop of line is twice the distance of the hotbeds plus twice the space between the two beds plus twice the distance from the hotbed to the supply header line. In this case, the hotbeds being 60 feet long, the length of pipe for one way would be about 132 feet, or 264 feet for a complete loop.

By above calculations, 18 gallons per minute was determined for the entire installation, which consists of 15 loops. Thus each loop will receive 1.2 gallons of water per minute. Since the length of the two beds is greater than 100 feet, 3/4-inch pipe will be used in the beds. Referring to the chart in Figure 11, for the 3/4-inch pipe at 1.2 gallons per minute, a resistance head of .9 foot per 100 feet can be expected. Since each loop consists of 264 feet of 3/4-inch pipe, the resistance per loop is 2.64 x .9, or 2.38 feet. There are 15 loops for the installation; so 15 x 2.38 equals 35.7 feet of head for the 3/4-inch heating lines.

The supply and return header lines at the head of the beds can be 1 1/4 inches in diameter, and assuming that the heaters and pump are within 35 feet of the hotbeds, then the total length of the header lines will be the width of the hotbeds as laid out (50 feet, including 10-foot alleys) plus the 35 feet to the pump, or 85 feet per line. For the two header lines this would be 170 feet. For all practical purposes it can be assumed that all the water from the pump passes through the total length of this line. From Figure 11 for a 1 1/4-inch pipe handling 18 gallons per minute of water, the resistance is 9.2 feet of head per 100 feet of pipe. So the total resistance for the header lines would be 1.7 x 9.2, or 15.64 feet of head. The total resistance that the pump would operate against then would be 35.7 plus 15.64, or 51.34 feet of head.

In this example the required pump volume was calculated as 18 gallons per minute and the resistance head as 51.34 feet of water. A direct driven motor-pump that will meet these requirements can be selected from a pump catalog. This would be a 3/4-inch centrifugal pump driven by a 3/4-h.p. electric motor.

Advantages and Disadvantages of Hot-Water System.—The chief

advantage of the hot-water system is the low cost of operation due to the plentiful source of natural gas in Louisiana. Butane gas can be used where natural gas is not available. The first cost of the pump, heater coils, and pipes makes it the most expensive system to set up, but according to operational results for the past several years, this high first cost is quickly offset by the low operational cost for a large hotbed system. It requires the same amount of labor for tending as the electric heating system. It has a low replacement or upkeep cost, as the pipes are never damaged when replacing the soil in the hotbed as is sometimes the case for the electric heating cable. Its chief disadvantage is that it cannot be installed on a small size hotbed since the smallest motor-pump unit and coil heater are too large and expensive for a small installation.

Operating the Hotbed

Thermostat Adjustment

The thermostat is the instrument that keeps the bed at the proper temperature when electric cable or circulating hot water is used. It should be checked before putting the hotbed into operation each spring. Some thermostats have degree markings on the adjustment screw dial. It should never be taken for granted that these graduations are correct until proved by testing. The temperature setting can be adjusted in the following manner: Place the thermostat bulb in a container of water which is heated to 85° F. as measured by a reliable thermometer. At this temperature the electrical contacts should separate or be adjusted to separate. Then cool the water to 80° F.; the contacts should then come together again. For adjusting the setting the adjustment screw on the thermostat can be turned counter-clockwise to raise the temperature and clockwise to lower the temperature setting.

When the proper thermostat setting has been determined, the bulb should be placed in the bed at the same level as the potatoes. A soil thermometer should be inserted in the bed to the depth of the potatoes and preferably located so that it can be read without disturbing the cover. The thermometer should be read daily to ascertain that the bed is heating properly. After the heat is turned on the bed should warm up to 80° to 85° F. in a couple of days.

Cover

It is necessary to have cloth, glass, glass substitutes, or plastic to cover the bed at night if economical operation is expected. In order to conserve fuel the cover should remain over the bed during cool, cloudy days.

Watering

The bed should be watered after the potatoes are placed in it. Watering thereafter will depend on the type of heat and weather conditions, but frequency of watering will be from once to twice a week.

Ventilation

When the sprouts begin to appear in the hotbed the cover will have to be rolled back from the beds on bright, sunny days from about nine in the morning until about five in the afternoon. If the cover is left over the bed during a hot summer day the plants may become scorched. After the plants become older the heat may be turned down and the cover left off to harden the plants before pulling for field setting, but danger of frost must be watched.

Storage

When the hotbed season is over, a little attention given the beds can prove a big saving over a period of years. A cloth or plastic cover will last several seasons if it is dried out, rolled up, and stored away in a dry place. The potato bedding soil should be removed and the bed aired until ready for refilling the next season. Electricity should be cut off from the bed and the thermostat stored out of the weather.

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